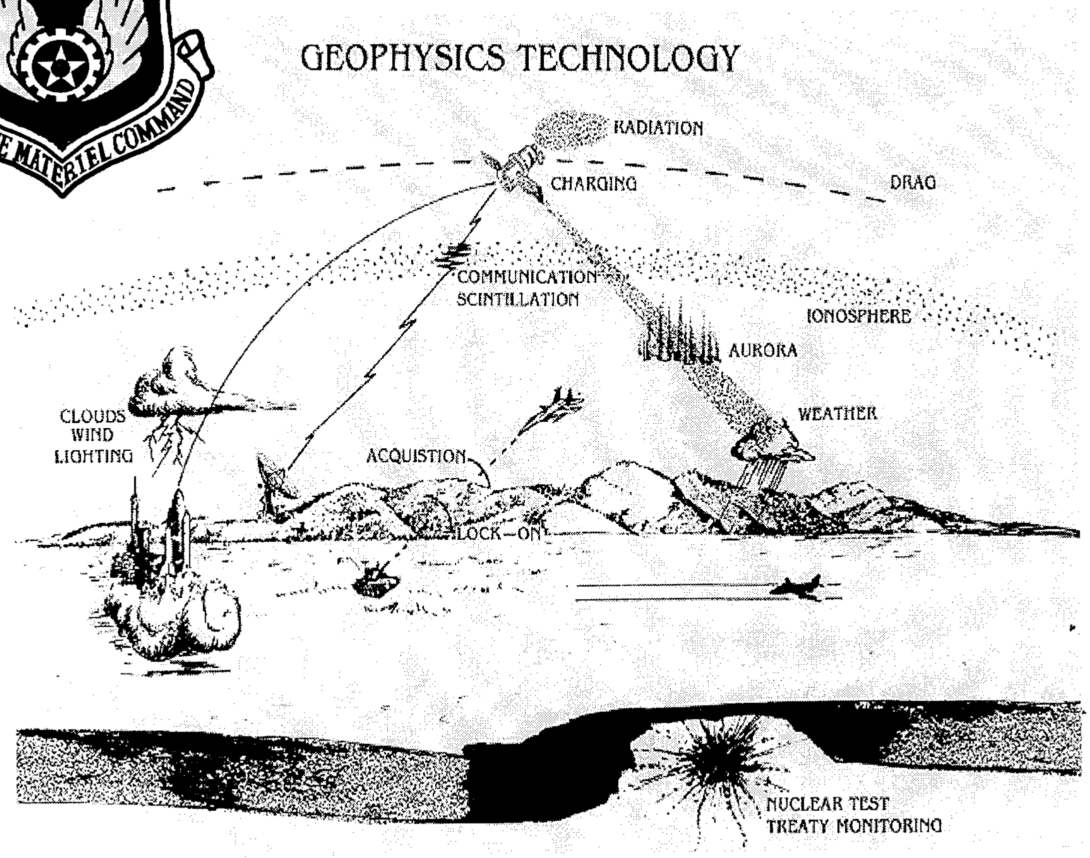
FY 96
GEOPHYSICS
TECHNOLOGY AREA PLAN



HEADQUARTERS AIR FORCE MATERIEL COMMAND
DIRECTORATE OF SCIENCE & TECHNOLOGY
WRIGHT-PATTERSON AFB OH

Note: This Technology Area Plan (TAP) is a planning document for the FY96-02 S&T program and is based on the President's FY96 Budget Request. It does not reflect the impact of the FY96 Congressional appropriations and FY96-02 budget actions. You should consult PL/XPG, DSN 478-3606, for specific impacts that the FY96 appropriation may have had with regard to the contents of this particular TAP. This document is current as of 1 May 1995.

Cleared for public release

DRAFT SF 298

1. Report Date (dd-mm-yy) January 1996	2. Report Type	3. Dates covered (from... to)
4. Title & subtitle FY 96 GEOPHYSICS TECHNOLOGY AREA PLAN		5a. Contract or Grant # 5b. Program Element #
6. Author(s)		5c. Project # 5d. Task # 5e. Work Unit #
7. Performing Organization Name & Address Phillips Laboratory 3550 Aberdeen Ave SE Albuquerque, NM 87117-5776		8. Performing Organization Report # PL-TM-96-1001
9. Sponsoring/Monitoring Agency Name & Address		10. Monitor Acronym 11. Monitor Report #

12. Distribution/Availability Statement Approved for public release; distribution is unlimited.

13. Supplementary Notes

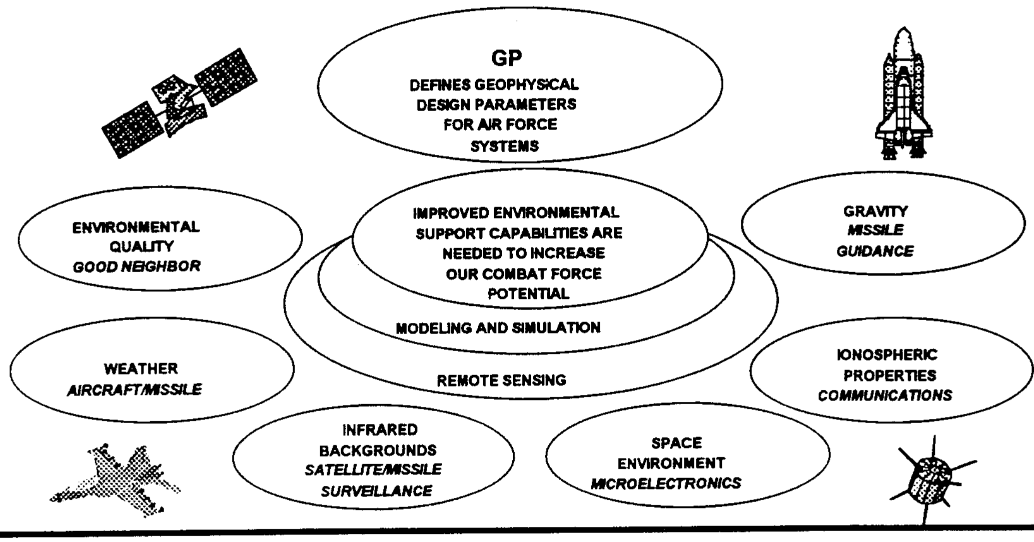
14. Abstract

The FY 96 Geophysics Technology Area Plan describes Phillips Laboratory's exploratory and advanced technology development in the field of geophysics. The document addresses user needs, goals, major accomplishments, and changes from last year for each geophysics thrust. Thrust 1 describes geophysics for space operations and communications. Thrust 2 covers geophysics for air and combat operations. Finally, thrust 3 addresses geophysics with corporate applications.

15. Subject Terms : Geophysics, technology area plan, TAP, space operations, combat operations, space radiation, weather, airborne signatures, optical and remote sensing, Phillips Laboratory

Security Classification of			19. Limitation of Abstract	20. # of Pages	21. Responsible Person (Name and Telephone #)
16. Report	17. Abstract	18. This Page			
Unclassified	Unclassified	Unclassified	Unlimited	39	Lt. Kevin Byrne COM (505) 853-3191 DSN 263-3191

GEOPHYSICS



VISIONS AND OPPORTUNITIES

The Phillips Laboratory (PL) develops and maintains the technology base to support AF requirements for space and missile systems. PL also develops and maintains the technology base for advanced weapons and geophysics beyond their space applications to support other AF and DOD requirements.

The environment in air and space:

* limits the operation,
* raises the cost, and
* degrades the performance of Air Force systems.

Geophysics science and technology (S&T) programs support Air Force and Army air and combat operations by improving the specification and forecasting, for longer periods and more precisely, of performance limiting environmental conditions wherever our forces operate.

Current efforts are increasingly turning to space to accomplish this. Contributing factors are:

* fewer personnel,
* fewer foreign bases, and
* the emphasis on stand-alone, forward-based, theater weather support systems with limited access to observing sites.

Geophysics S&T can reduce the adverse effects of the aerospace environment that limit the operation of present and the performance of future AF systems. Geophysics seeks to understand the physics of the natural environment in order to:

* determine its effects on military systems,
* develop techniques and procedures to mitigate these effects, and
* to exploit them if possible.

Geophysics technology programs support all developmental and operational space activity. The directorate's technology programs provide critically important information to ensure successful use of space by providing the design parameters necessary to enable satellites survive in its hostile environment.

The geophysics S&T program is responding to:

* the new emphasis on tactical warfare,
* the recent dramatic political and military changes occurring in the former Soviet Union, Eastern Europe, and the Middle East,
* the emerging tactical and strategic threats from third world countries.

These have changed the potential threat to the U.S and our allies. The Air Force will now need to support conventional war-fighting capability in all parts of the

world. Nuclear deterrence has given way to counter-proliferation as biological and chemical weapon threats spread. Systems to detect clandestine nuclear tests must consider an ever increasing number of countries. Strategic conventional weapons benefit from the Global Positioning System (GPS) and the joint Phillips and Wright Laboratories Ballistic Winds program.

Operation Desert Storm dramatically demonstrated the tactical utility of space systems to our fighting capability. Systems that more completely and accurately sense environmental conditions from space will be increasingly important in helping the Air Force carry out its doctrine for multiple limited wars. The development of such systems is a continuing vision for geophysics S&T.

The Geophysics Directorate continues to increase its involvement with operational customers. More than twenty of its scientists and engineers are members on various Technical Planning Integrated Product Teams (TPIPT's). These individuals are working with operators and designers of new systems to identify solutions to requirements that involve the natural environment. The Technology Needs that are products of the MAJCOM Mission Area Planning are welcome validations of core Geophysics programs.

The Geophysics thrusts are now aligned with operational customers:

* Geophysics for Space Operations and Communications,
* Geophysics for Air and Combat Operations, and
* Geophysics with Corporate Applications.

These thrusts directly address Air Force needs and clearly communicate to the warfighters how the results of Geophysics research and development improve operational capability.

A key element of the geophysics long term vision is the integration of the natural environment into the growing Modeling and Simulation initiative within the DOD.

* Geophysics is developing signature prediction models, based on in-flight calibrated measurements, which properly assess the interaction of the target with the environment.
* Effective simulations of targets, backgrounds, weapons, and countermeasures could replace traditional flight testing to evaluate electro-optical weapon systems performance.
* Simulations can stand alone or drive hardware-in-the-loop simulators for organizations like the AF Electronic Warfare Effectiveness Simulator (AFEWES).

Geophysics contributes to environmental quality. Current and planned Geophysics S&T programs produce technology needed by the Air Force to:

* Comply with environmental laws,
* Minimize the impact of Air Force operations on the global and local environment, and
* reduce the cost of clean-up and compliance.

The directorate initiated a program with the University of Massachusetts to bring graduate students, faculty members, and Geophysics Directorate scientists together to conduct joint research.

* Last summer five professors and one graduate student from the University of Massachusetts were resident researchers at the Geophysics Directorate.
* The goal for FY96 is to complete a similar arrangement with MIT.

This plan has been reviewed by all Air Force laboratory commanders/directors and reflects integrated Air Force technology planning. We request Air Force Acquisition Executive approval of the plan.

RICHARD R. PAUL
Brigadier General, USAF
Technology Executive Officer

RICHARD W. DAVIS, Colonel, USAF
Commander
Phillips Laboratory

CONTENTS

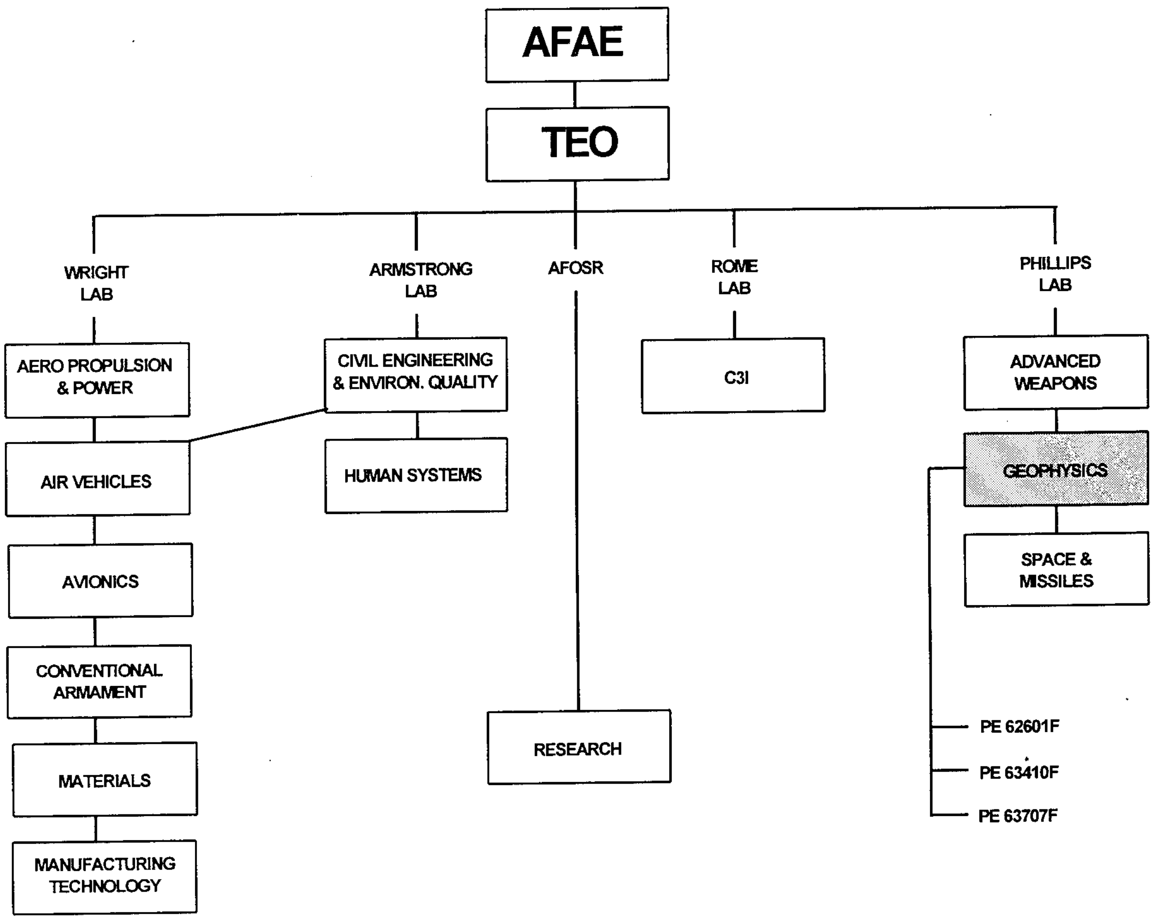


Figure I.1 Air Force S&T Program Structure

INTRODUCTION

BACKGROUND

Geophysics Science and Technology (S&T) advances Air Force war fighting capabilities by providing technology to define, understand, and control interactions between systems and their environment. These advances are accomplished through environmental programs in the earth, atmospheric, and space environmental sciences. The Geophysics Technology Area (TA) is conducted within the Geophysics Directorate of the Phillips Laboratory (PL). (Figure I.1).

The Geophysics S&T goal is to understand and specify the environmental effects on military systems, mitigate the detrimental effects of the environment, and exploit the properties of the environment for system operation. Because many Air Force systems are adversely impacted by the environment, Geophysics S&T, when applied early in system design, will lead to more affordable, supportable, and reliable systems. The consequences of overlooking adverse environmental interactions early in the development cycle have proved severe. It is cheaper to identify and eliminate adverse effects early than to redesign later.

MAJOR ACCOMPLISHMENTS

Based on extensive in-flight measurements, a comprehensive infrared predictive model of the C-17A cargo aircraft was developed. This SPIRITS (Spectral and In-band Radiometric Imaging of Targets and Scenes) model incorporated innovative plume enhancements for the C-17A's high-bypass turbojet engines, flap heating from thrust diverting flaps, and the MODerate Resolution TRANsmission (MODTRAN 3) and MOderate Spectral Atmospheric Radiance and

Transmittance (MOSART) environmental models. Model predictions were generated to drive the AF Electronic Warfare Effectiveness Simulator (AFEWES) hardware-in-the-loop simulator for flare effectiveness studies, as well as planned inclusion in missile flyout models such as Digital Infrared Seeker and Missile Simulation (DISAMS) and MOSAIC.

The Photovoltaic Array Space Power Plus diagnostics (PASP Plus) experiment was launched 3 Aug 94 as a major part of the APEX satellite with the aid of a PEGASUS booster. PASP Plus is evaluating the impact of the space environment upon the operations of twelve different solar cells in 18 configurations. Tests seek to find the best voltages at which to run the cells. In addition, the long-term degradation of the solar cells will be assessed.

Successfully demonstrated the robustness of radiation measurements from the Defense Meteorological Satellite Program (DMSP) SSM/T-2 water vapor sounders on vehicles F11 and F12. Vehicle F12 was launched in Aug 94 and F13 in Mar 95 with three Phillips Lab space sensors. They measure (at 840 km) plasma concentrations and temperatures (SSIES-2), auroral particle fluxes (SSJ4), and the earth's magnetic field (SSM). The first two data sets are real-time inputs for "space weather" models used at 50th Weather Squadron (50WS). The magnetic field data will be used at 50WS in the future when advanced coupled magnetospheric models, now under development, are installed.

A well-publicized scheme, proposed by a physicist at the University of California, to save the stratospheric ozone layer from destruction by chlorofluorocarbons was shown not to be feasible. The proposed scheme involved converting atomic chlorine to benign negative ions. Geophysics researchers proved that negative chlorine ions are not stable in the stratosphere and that the scheme is impossible. This work potentially will save millions of US research dollars which might have been used to pursue the idea.

Phase 1 of the Support of Environmental Requirements for Cloud Analysis and Archive (SERCAA) program was completed. Funded by the Strategic Environmental Research and Development Program (SERDP), this research effort produced algorithms for analysis of satellite cloud image data. The Phase 1 algorithms will be transitioned to the Department of Defense (DOD) Satellite Analysis Central Site for inclusion in the Cloud Depiction and Forecast System - II, an advanced global weather analysis and prediction system for support of military operations. In addition, SERCAA Phase 2 algorithms and data products will provide cloud climatology for global climate modeling.

AF S&T FUNDING: The Geophysics S&T portion of the Air Force S&T budget is shown in Figure I.2. Funding is based on the FY95 President's Budget Request and actual funding may change based on possible Congressional action. Despite the relatively small funding, Geophysics S&T transitions significant technology to designers and operators of Air Force systems. In FY93, approximately 70 technology transitions were documented.

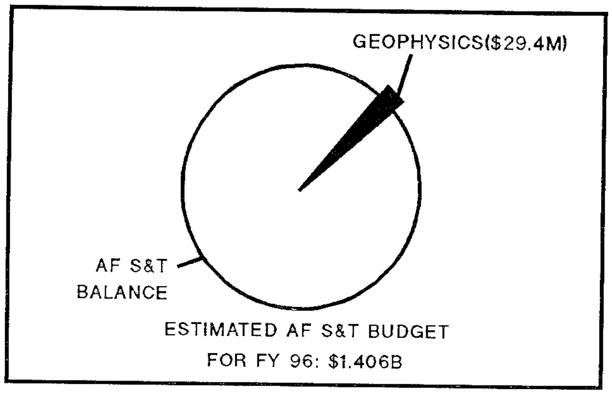


Figure I.2 Geophysics S&T versus AF S&T

Geophysics S&T has a program balance that matches current Air Force direction, with the bulk of its funding in exploratory development. The substantial in-house basic research program supports the exploratory development program, and a modest advanced development program provides the technology developed in the exploratory development program to AF customers. Geophysics differs from other technology areas in that the 6.3A program delivers many S&T products directly to customers for operational development, such as the 50WS, rather than to a System Program Office (SPO).

GEOPHYSICS S&T THRUSTS: Geophysics S&T has three thrusts, listed in Figure I.3

THRUST 1 - Geophysics for Space Operations and Communications: The Space Effects on Air Force Systems Sub-thrust:

* Defines, models, and predicts the solar and space environment for AF and DOD operations throughout the world,

THRUST NO.	TITLE
1.	Geophysics for Space Operations and Communications
2.	Geophysics for Air and Combat Operations
3.	Geophysics with Corporate Applications

Figure I.3 Geophysics S&T Thrusts

* Establishes a space forecast capability and develops operational sensors for the measurement of space weather,
* Advances technology in the area of space system environment interactions and accelerates the insertion of new technologies into AF satellite systems through space tests of prototype systems,
* Develops techniques to mitigate environmentally-induced degradation of space systems,
* Supports the AF global responsibility for surveillance and communication, and
* Transmits solar/space environment models and codes to the DOD users through the 50WS.

The Ionospheric Effects on Air Force Systems Sub-thrust:

* Develops the technology to predict when and where ionospheric disturbances will interrupt operational Air Force systems.
* Specifies atmospheric drag effects for satellite tracking and reentry predictions,
* Measures and models space debris,
* Explores the feasibility of modifying the ionosphere for Air Force exploitation,
* Measures and develops models of ultraviolet earth backgrounds for designing space-based ionospheric sensors and space surveillance sensors, and
* Develops instrumentation and models for geodesy and gravity to improve Air Force autonomous navigation, inertial testing, precise satellite positioning, and motion sensing systems.

The Optical and Infrared Technology Sub-thrust:

* Measures infrared and optical backgrounds from ultraviolet to millimeter wavelengths from which target signatures observed by missile launch warning, tracking, and interceptor systems must be discriminated,
* Measures stellar position and spectral reference sources required for on-board calibration of space-based infrared and optical sensors on surveillance and tracking satellites,
* Models the infrared and optical backgrounds and transmissivity needed to optimize the performance of missile launch warning, tracking, and interceptor systems,
* Provides integrated codes describing infrared and optical backgrounds and transmissivity for real-time battlespace engagement simulations,
* Develops new electro-optical sensor technologies for target detection and tracking.

THRUST 2 - Geophysics for Air and Combat Operations: The Weather Impact on Air Force Systems Sub-thrust develops new techniques for measuring, processing, analyzing, modeling, and predicting meteorological properties which impact the Air Force mission. Much of this technology transitions directly to the Air Weather Service (AWS), which in turn supports the entire Air Force and Army. Emphasis is on developing algorithms for use in designing and operating Air Force systems. Included are:

* Techniques for automated meteorological analysis and display,
* Tactical weather observing and forecasting, and
* Remote sensing and analysis techniques.

The Optical and Infrared Remote Sensing Sub-thrust develops new environmental monitoring sensor systems for aircraft and ground sites, performs measurements and develops simulations for evaluating the performance of advanced weapon systems, and develops standoff chemical detection capabilities. Much of this technology transitions directly into improved warfighting capabilities of operational commands, such as Air Force Special Operations Command (AFSOC), Air Combat Command (ACC), and Air Mobility Command (AMC). Examples include:

* Remotely sensing ballistic winds, clouds, and aerosols with Lidar.
* Remotely sense chemical and biological agents, chemical fugitive emissions, and minor atmospheric species,
* Making passive calibrated visible and infrared measurements of aircraft and rocket signatures (such as the B-2, F-117, and the F-22) from the

Flying Infrared Signatures Technology Aircraft (FISTA) II airborne platform, and

* Developing infrared predictive models of specific targets (such as the C-17A, B-52H, C-130H, and the Air Launched Cruise Missile (ALCM)) that include all important environmental effects and are used to provide accurate simulations under all operational conditions.

THRUST 3 - Geophysics with Corporate Applications: The Terrestrial Effects on Air Force Systems Sub-thrust advances technology in earth motions and seismology to overcome Air Force problems in nuclear test monitoring and test ban treaty verification.

The Geophysics for Synthetic Environments Sub-thrust develops interfaces between models of the environment that simulate the aerospace environment (space and near-earth environment, the ionosphere, the weather, and the optical/infrared environment) and effects on weapons systems. Expert user systems provide seamless access and options to employ the directorate's geophysical codes in specific user environments. By providing these convenient interfaces, the Geophysics codes will become the standard environments for use in all DOD activities from system design, acquisition, test and evaluation, operational planning, war gaming, and training. Examples include obtaining IR signatures and predictive models of aircraft for Air vehicles.

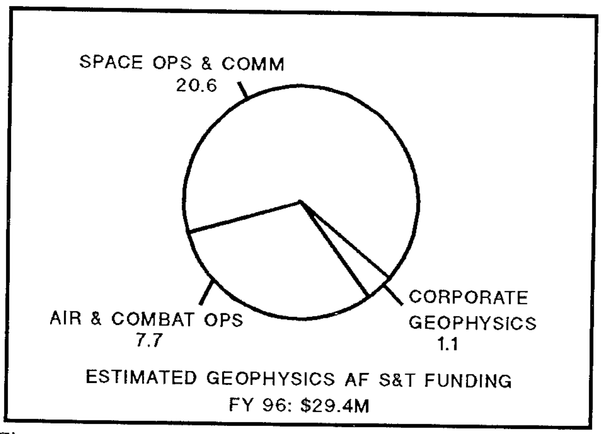


Figure I.4 Geophysics Major Thrusts

The Geophysics for Environmental Quality Sub-thrust exploits relevant advances in geophysics sensor technology, algorithm and model development, and data fusion to establish compliance of AF systems with environmental regulations, to reduce the impact of AF systems on the environment, and to reduce the cost of facilities clean-up.

The distribution of Air Force S&T funds in these thrusts is shown in Figure I.4.

RELATIONSHIP TO OTHER TECHNOLOGY PROGRAMS

RELATIONSHIP TO OTHER AF S&T TAs: Geophysics is a pervasive technology that directly interacts with all of the other Air Force S&T technology areas. Geophysics S&T researchers have collaborative programs in Avionics, Space and Missiles, Advanced Weapons, Command, Control, Communications, and Intelligence (C^3I), Civil Engineering and Environmental Quality, and Research. Cooperative programs exist in other areas. Examples include obtaining infrared (IR) signatures and predictive models of aircraft for Air Vehicles; providing spacecraft environment interaction codes to Space and Missiles; developing optical turbulence specification techniques for laser propagation needs in Advanced Weapons; providing space radiation human hazard data to Human Systems; and conducting joint ionospheric RF (radio frequency) propagation experiments with C^3I.

Within Phillips Lab, Geophysics S&T receives extensive support from the Aerospace Engineering Division in the Space and Missiles TA Space Experiments Directorate. Geophysics relies on them to provide engineering, fabrication, and pre- and post-launch support for geophysics rocket and space experiments.

Geophysics works with the Advanced Weapons TA on using Lidars for remote sensing. Advanced Weapons leads in using Lidar for standoff detection of chemical and biological agents for counter-proliferation purposes. Geophysics works with the Avionics TA from Wright Laboratory in using Lidar to measure winds aloft to aid in defining trajectories of bombs. Avionics leads in using Lidar for remote wind sensing to correct the trajectories of cargo, pallets, and projectiles originating from aircraft.

INDUSTRIAL RESEARCH AND DEVELOPMENT (IRAD): A comparison of the IRAD funds invested by industry in geophysics with the Geophysics Directorate budget is one measure of industrial investment in geophysics technology.

Approximately 100 IRAD projects (out of 8000) are in the Geophysics thrust areas. The IRAD funding in geophysics is less than 10% of the total Geophysics S&T funding, underscoring a critical conclusion of the DOD 1994 Laboratory Infrastructure Capabilities Study. If the DOD doesn't support the battlespace Environment S&T, this required "direct support to the warfighter" will not be available, since there is only a very small commercial market for this DOD core technology.

SMALL BUSINESS INNOVATION RESEARCH (SBIR): The SBIR program has helped Geophysics S&T overcome this lack of IRAD. Geophysics S&T has been a strong participant in the SBIR program since its inception and the program has provided the "start-up" capital for innovative ideas that have benefited Geophysics S&T.

COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENTS (CRDAS): Geophysics S&T also leverages its resources through CRDAs with industry as permitted by the Federal Technology Transfer Act of 1986. Geophysics S&T is completing its eighth CRDA. These CRDAs will avoid costs by having industry develop needed technology that otherwise would have to be developed by Geophysics S&T. Geophysics CRDA partners invest more than $500K in these joint programs.

SPACE TECHNOLOGY INTERDEPENDENCY GROUP (STIG): The space research programs in the Geophysics Directorate are coordinated through the STIG Space Environment and Effects Technical Committee. A current emphasis is the creation of roadmaps that contain research programs underway and planned by the Air Force and National Aeronautical and Space Administration (NASA) primarily and other DOD agencies, where possible. Committee membership also includes representatives from the National Oceanic and Atmospheric Administration (NOAA). Several cooperative programs with the Navy and NASA are described in the program description.

INTERNATIONAL: The Geophysics Directorate has cooperative research and developments arrangements (Data Exchange Agreements, Memoranda of Understanding, etc.) with seven countries. The leverage to Geophysics from the European Space Agency Infrared Space Observatory is estimated to be $500-800M.

INTERAGENCY: Geophysics S&T programs are well coordinated with other Federal agencies and by two additional mechanisms within the DOD, in addition to the STIG. The Federal Committee for Meteorological Services and Supporting Research provides coordination and elimination of duplicate activities for the geophysics research being conducted by all Federal agencies. The Joint Director of Laboratories (JDL) Environmental Sciences Panel reviews all service programs for redundancy. In addition, the Deputy Director of Defense Research and Engineering (Research and Advanced Technology), Office of Environmental and Life Sciences, reviews DOD geophysics research at an annual S&T review with briefings by all DOD agencies involved in geophysics research. Phillips Lab Geophysics Directorate monitors and shares results with the Defense Nuclear Agency program on space environment models.

CHANGES FROM LAST YEAR

IMPACT OF PROJECT RELIANCE: The Air Force atmospheric sciences S&T program now emphasizes satellite imagery and sounding exploitation for theater and global depiction and weather prediction purposes which focus on cloud parameters. Numerical weather prediction applications rely on Navy models which are used to evaluate new data assimilation strategies. Funds have been transferred and an AF scientist is presently assigned to a Navy lab. Diffusion modeling has been transitioned to the Army.

The infrared and optical background and transmission codes developed under the Optical and Infrared Background Effects S&T program are provided to the Navy and to the Army for inclusion in their integrated target and background simulation codes. These include the Synthetic Scene Generator Model (SSGM) and the Optical Signatures Code as well as Defense Modeling and Simulation Office (DMSO) simulation codes.

THRUST 1: GEOPHYSICS FOR SPACE OPERATIONS AND COMMUNICATIONS

USER NEEDS

Control and exploitation of space is part of the Air Force mission. Important to achieving this goal is the development of techniques (including sensors and operational models) to accurately specify and forecast the battlespace environment and its effects on Air Force systems and operations. The pervasive nature of these environmental effects is evident.

Space-Based Weather and Environmental Monitoring reflects that weather and environmental monitoring are backbone functions which cut across all commands and all military activities. All commands include weather and environmental monitoring to some extent in a variety of Mission and Functional Area Development Plans. Relevant extracts include:

Space Surveillance: Detection, tracking (including orbital changes), identification, and cataloging of all man-made objects in space requires very accurate specification of upper atmosphere neutral density and other environmental conditions.

Navigation: The Navigation Systems Modernization Plan requires increased accuracy through carrier phase ambiguity resolution and multipath reduction algorithms for user equipment as a near term need applicable to all Global Positioning System (GPS) users. Improved ionospheric modeling is needed to augment GPS by utilizing geosynchronoous satellites such as Advanced MILSATCOM. Similar requirements for improved GPS are also described in the ***Satellite Control*** and ***Reconnaissance, Surveillance and Intelligence (RSI)*** plans.

Military Satellite Communications: Notes the need toto extend communications coverage into the polar region, which is subject to intense ionospheric disturbances. There is a need to combat scintillation effects associated with polar and equatorial ionospheric disturbances.

Force Application: There is a need to characterize the effects of intense local plasmas that surround very high speed aerospace platforms and to develop light weight, high efficiency solar arrays for MILSTAR III, with a technology freeze date of 2000.

Satellite Control notes that critical RF communication links are susceptible to interruption by environmental disturbances triggered by anomalous solar or geomagnetic space conditions. These disturbances increase the drag on satellites, alter their orbits, can cause high frequency (HF) blackout at high latitudes, alter the frequencies for HF communication links, and create ionospheric scintillations which disturb ultra-high frequency/extremely-high frequency (UHF-EHF) communications.

Theater Battle Management (TBM): Includes improved Over-The-Horizon (OTH) radar for early launch detection and assessment. ACC, North America Air Defense Command (NORAD) and US Southern Command (USSOUTHCOM) also identify OTH radar as a solution for current C3I deficiencies; and state that OTH radar will be useful for counter-drug surveillance. Reliable use of OTH radar requires accurate specification and forecasting of the state of the ionosphere, which controls OTH operational performance.

The Technology Master Process builds, in Air Force Materiel Command (AFMC), on Mission and Functional Area Plans, developed in the MAJCOMS and HQ AF.

GOALS

Specify and model the hazardous charged particle environment near earth and throughout the magnetosphere so designers can achieve required performance with minimum life-cycle costs. Measure key solar and interplanetary parameters for specification and forecast models to minimize severe space system degradation or failure.

Obtain a global, real-time, capability to accurately specify and forecast the state of the ionosphere, including the ability to provide timely warning of when, and how severely, ionospheric disturbances will disrupt C3I systems. Investigate ionospheric phenomena degrading GPS accuracy.

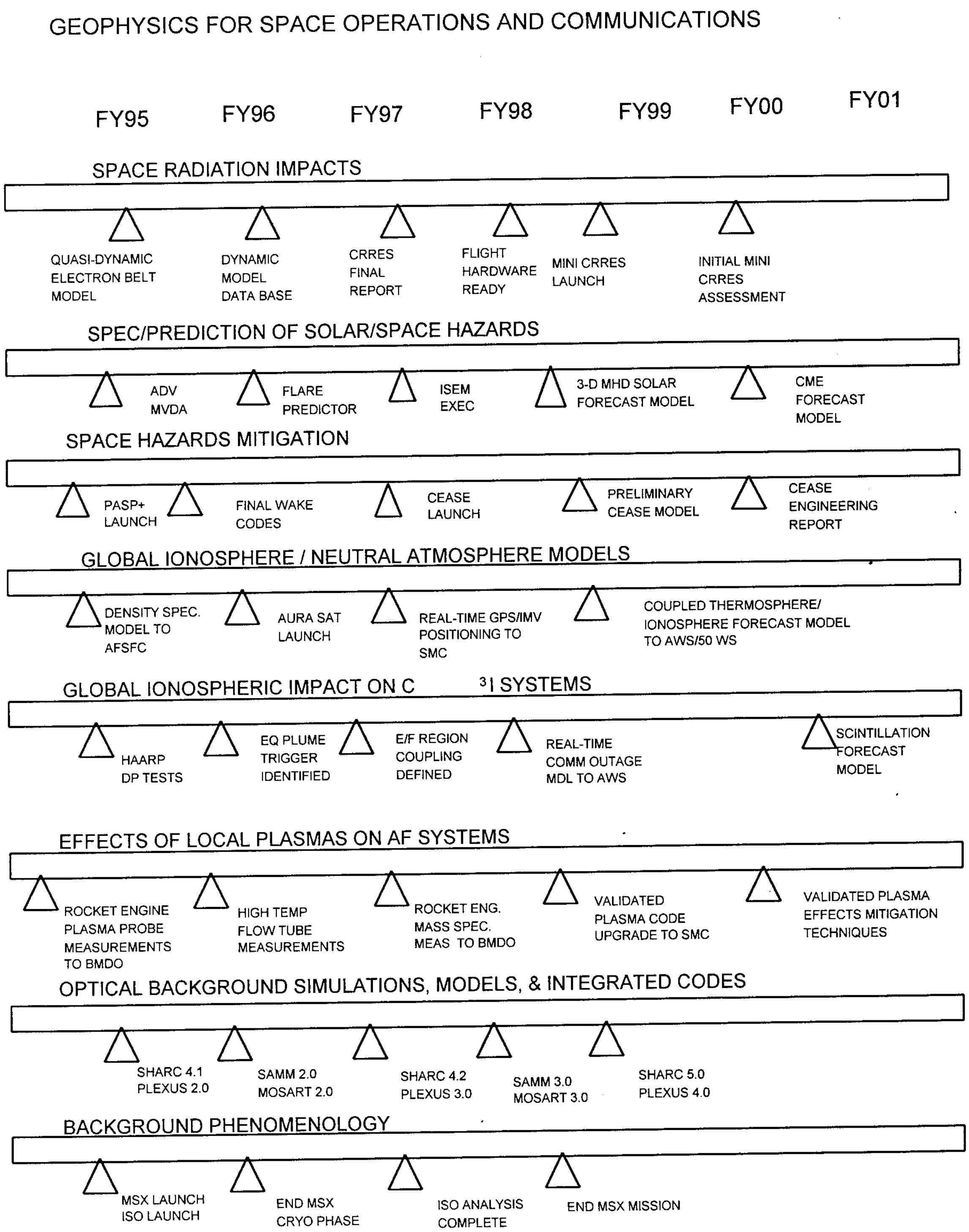


FIGURE 1.1 Geophysics for Space Operations and Communications

Specify and predict the earth's gravity and upper atmosphere neutral density with accuracies to meet operational requirements for satellite tracking, reentry predictions, detection of orbital changes, determination of satellite lifetimes and on-board fuel requirements, and space debris hazard assessments.

Combine the separate energetic charged particle, ionospheric, and neutral density models into an Integrated Space Environment Model system that monitors the environment in which space systems operate and warns of hazards to space systems and on earth, for example, power transmission grids.

Characterize the plasmas generated around reentry vehicles and other hypervelocity platforms; quantify their effects on GPS radio signals; and, develop chemical techniques to control plasmas to alleviate radio blackout and increase guidance accuracies.

Characterize and measure the infrared and optical wavelength signatures of backgrounds and targets (including missile plumes) needed to discriminate target from their backgrounds.

Develop/validate computer codes to simulate infrared and optical atmospheric transmissions and backgrounds and celestial backgrounds to allow designers to optimize the performance of infrared and optical sensors for surveillance, tracking, and interceptor systems at minimum cost.

MAJOR ACCOMPLISHMENTS

The PASP Plus experiment was launched 3 Aug 94 to evaluate the impact of the space environment upon the operations of twelve different solar cells in 18 configurations. Voltage biasing tests seek to find the best voltages at which to run the cells while the long-term effect of the environment upon the solar cells will be assessed.

The Solar Wind Interplanetary Measurements (SWIM) experiment was launched on NASA's WIND satellite on 1 Nov 94. SWIM will provide real-time solar wind data to the 50th Weather Squadron starting Mar 19, for their space weather model forecasts.

The DMSP spacecraft F-12(S-11) was launched 29 Aug 94 and F-13 (S-13) 24 Mar 95. Three Phillips Lab space sensors will measure (at 840 km) plasma concentrations and temperatures (SSIES-2), auroral particle fluxes (SSJ4), and the earth's magnetic field (SSM). The data two data sets are real-time inputs for "space weather" models used at 50th Weather Squadron (50WS). The magnetic field data will be used at 50WS in the future when advanced coupled magnetospheric models, now under development, are installed. The space sensors for DMSP S-17, to be launched several years from now, were delivered to the SPO.

CRRESPRO, a quasi-static model of the Earth's proton radiation belt, was developed based on data obtained with the Combined Release and Radiation Effects Satellite (CRRES). CRRESPRO predicts proton omnidirectional fluence per year and integral omnidirectional fluence per year at selected energies in the range 1-100 MeV for a user-specified orbit. The model has been provided to Special Access Projects and to many Space and Missile Systems Center (SMC) contractors.

A study showed that large ground-based solar coronagraphs and medium-aperture space-borne coronagraphs can detect orbiting space debris in a size range presently unobtainable by ground-based instruments. A "white paper" on DOD applications in this area has been delivered to Ballistic Missile Defense Organization (BMDO). Interactions were established with MIT/Lincoln Lab/GEODSS to improve debris observing techniques.

The Parameterized Real-Time Ionospheric Specification Model (PRISM), scheduled for full operation at the 50WS during FY 95, has been shown to be twice as accurate as its predecessor. This specification model uses real-time data to extrapolate ionospheric conditions and the propagation environment worldwide. An Ionospheric Forecast Model was also delivered to 50WS, where it will be transitioned for operational use. These models are used to predict radio propagation worldwide under any conditions.

The Vector Spherical Harmonic (VSH) model for specifying global neutral atmosphere densities was delivered to Air Force Space Command (AFSPC) for validation. The goal is to specify and (ultimately) forecast neutral densities to within 5% to satisfy requirements for accurate models of satellite drag.

Phillips Lab provided special scintillation forecast notices, based on the research data base, for the Korea/Japan and Rwanda/Zaire regions for AF system operators. Feedback indicated that these had significant impact. A second Remote Access Scintillation Warning System (RASWS) was deployed in the equatorial region. The RASWS systems can be accessed by PL for research purposes and by AFSPC controllers for real time specification of ionospheric disturbances that degrade satellite communications.

In an effort supporting the Ionospheric Measuring System and Sacramento Air Logistic Center, a technique to automatically calibrate ground-based measurements of total-electron-content (TEC) was developed for ionospheric correction algorithms required by space surveillance radars. Other support included an upgrade of the 50WS Digisonde Network (DISS).

Significant progress was achieved under the High Frequency Active Auroral Research Program (HAARP) with the construction and testing of a Development Prototype (DP) HF transmitting array in Gakona, Alaska.

Ion reaction kinetics measurements were extended from 1300K to 2000K (the highest temperatures ever achieved), using a one-of-a-kind laboratory chamber equipped with a furnace. The high temperature data are required to characterize plasmas which degrade sensor performance and guidance accuracy associated with very high speed aerospace vehicles. In a related activity, high temperature RF transmission tests were conducted in the Arnold Engineering Development Center Arcjet facility to study the performance of GPS antennas when surrounded by intense local plasmas.

Models of the production of IR backgrounds in the upper atmosphere by hyperthermal atom reactions have been developed. The impact of hyperthermal atom reactions on infrared backgrounds was determined. These results are being incorporated in the Synthetic High Altitude Radiance Code (SHARC) and SHARC and MODTRAN Merged (SAMM) codes used by SMC and BMDO to simulate infrared backgrounds in the upper atmosphere during the development of surveillance, tracking, and interceptor systems.

Codes to generate two-dimensional images of IR backgrounds containing non-stationary stochastic structure have been developed to support the performance and cost optimization of missile launch warning, tracking and interceptor systems. The SHARC code provides in-band mean radiance and the statistical structure parameters. The Synthetic Atmospheric Structure (SASS) code turns the SHARC 4 outputs into structured radiance images.

Infrared and optical background and transmission codes were developed and distributed to support SMC and BMDO surveillance, tracking and interceptor systems including the Space Based InfraRed system and Theater High Altitude Area Defense SBIRS and THAAD:

* Beta test versions of the MODTRAN 3 and MOSART 1.30 codes to calculate ultraviolet (UV) to millimeter wave transmission and backgrounds in the lower atmosphere.

* The Phillips Laboratory Expert Unified Simulator (PLEXUS) 2.0 code providing expert system access to the Fast Atmospheric Signature CODE (FASCODE), MODTRAN, SHARC, and the Celestial Background Scene Descriptor (CBSD) codes.

SKIRT II (Spacecraft Kinetic InfraRed Test) was successfully flown on the Space Shuttle in Feb 94 to collect IR data on spacecraft-atmosphere interactions, shuttle glow, thruster plumes, and gas releases. Key findings have transitioned to SMC.

Key optical and infrared atmospheric background data from several highly successful space Shuttle and rocket-borne experiments were transitioned into background codes for operational use.

CHANGES FROM LAST YEAR

The Space Weather And Terrestrial Hazards (SWATH) experiment has been put on hold by BMDO. SWATH is a satellite experiment to study the sun and to track space debris in the upper thermosphere of the earth. The coronagraph structure and its mirrors have been built.

The Advanced Density Satellite (ADS) was lost during launch due to rocket failure, delaying availability of the data and planned models. This will

delay delivery of improved operational global neutral density specification and forecast models. The experiment will be resubmitted for launch. More than 70% of the AF payload is already available from flight spares.

Research with the HAARP Development Prototype HF transmitting array in Alaska, following completion of testing in FY95, is changed to assessing the viability of exploiting ULF/ELF/VLF waves generated in the ionosphere for the detection of underground tunnels or structures. Research using HAARP to characterize the background ionospheric and electrojet conditions has been postponed indefinitely.

Emphasis continues to shift to tactical and theater warfare environments and away from the strategic environment as a result of changing AF and BMDO missions. Of greatest importance is the increased emphasis on spatial and temporal structure in optical and infrared backgrounds in the upper atmosphere and, in the lower atmosphere, for sensor lines-of-sight that are close to or below the horizon.

The delivery of all the BMDO-supported optical background codes continues to be substantially delayed owing to severe 6.3 funding cuts. Data analysis required to transition data from the Cryogenic InfraRed Radiance Instrumentation for Shuttle (CIRRIS) 1A, SPatial/spectral Infrared Rocketborne Interferometric Telescope (SPIRIT) II, and EXcitation by Electron DEposition (EXCEDE) III field programs to the background codes has been reduced, delaying required upgrades of the optical and infrared background codes.

MILESTONES

Improvements in specification and modeling of the static and dynamic behavior of the Earth's radiation belts are essential for AF/DOD space systems designs and operations.

Radiation belt products include:

* Advanced quasi-static radiation belt models will be formulated and validated by FY96,
* Energetic particle models and simulations will be transitioned to the SMC in FY96 and to 50WS in FY97,
* Dynamic radiation models will be transitioned to SMC and industry in FY98, and
* A follow-on Compact Radiation Effects Satellite (CRES) payload to characterize high energy particles (greater than 8 MeV) will be designed by FY97.

In FY96, techniques for compensating atmospheric turbulence with adaptive optics will markedly improve images of impending flares and other solar activity.

Advanced technology products include:

* The Charge Hazards And Wake Shield (CHAWS) Experiment will be launched for a second time on STS-75 during May 95. This experiment will provide a detailed picture of the electrical structure (and possible damaging high voltages) in the wake of a large space object, the joint U. Houston/NASA the Wake Shield Facility.
* An autonomous active Charge Control System (CCS) to prevent charge buildup on satellites is scheduled for launch on a DSCS satellite during the 4QFY95.
* The Shuttle Potential and Return Electron Experiment (SPREE) will be reflown with the Tethered Satellite System (TSS) on STS-75 during 2QFY96. While TSS was deployed only 268 m rather than the 20 km planned during the first flight in Jul 92, SPREE did obtain useful data in the vicinity of the Shuttle in regard to Shuttle charging. SPREE can observe electrons with energies from 10 eV to 10 KeV.
* The Compact Environmental Anomaly Sensor (CEASE) will be flight-ready in FY96 for launch on STEP-5. CEASE warns satellite operators of environmental conditions likely to cause anomalous spacecraft operations.
* The Space Waves In Plasmas Experiment (SWIPE) is expected to be launched on the joint Canadian/NASA OEDIPUS rocket in FY96. SWIPE will test the impact of the environment upon space-borne HF antennas.

* FY96 transition of a model for wake-region charging phenomena,

* New charging algorithms to assess spacecraft-plasma interactions (FY97), and

* Characterization of mechanisms affecting the performance of space-based radio transmitters in FY98.

Data from ground- and space-based sensors will be used in FY96-FY99 to update specifications of the ionosphere, neutral atmosphere, and space-debris environments.

* During FY96 the Ionospheric Forecast Model (IFM) will be validated by the 50WS for operational use. The PRISM ionospheric specification model will be extended to geosynchronous altitudes (22,000 km) in FY96 and will be coupled with a thermosphere model for delivery to HQ AWS in FY97.

* Owing to loss of the ADS neutral density satellite in the launch failure of the STEP-1 mission in FY94, new ADS sensors and hardware will be developed during FY96-FY97, with re-launch of a new atmospheric-density satellite in FY98. The goal is to provide the capability to specify densities between 160-500 km with less than 5% error.

* During FY96-FY97 the accuracy of the operational Wide Band Model (WBMOD), used by AWS and 50WS to warn operators of ionospheric scintillations that seriously disrupt C3I systems, will be greatly improved by incorporation of scintillation data now acquired at numerous sites in the polar and equatorial regions, including data from RASWS monitors in Panama and Saudi Arabia deployed in FY95. In a related activity, a global C3I outage warning system network and display will be implemented for AFSPC in FY96.

* Research using the HAARP DP transmitter and diagnostics in Alaska will begin in FY96 to assess the viability of HAARP as a tool for detection of underground tunnels and structures.

* The degradation of RF transmissions passing through plasmas generated around aerospace vehicles will be measured in FY96 at shock tunnel, plasma arc, and ballistic range facilities. Chemical and other techniques to mitigate deleterious effects will be tested and evaluated in FY97-FY99.

Space data will be collected and analyzed to characterize infrared and optical backgrounds. Laboratory measurements will be performed to transition the space data into improved models and codes needed to optimize the cost and performance of missile launch warning, tracking, and interceptor systems.

* The Mid-course Space Experiment (MSX) will be launched in FY95, providing critically needed data on spatial structure and variability in hard earth and earth limb backgrounds and key data on celestial backgrounds.

  ** During FY96-00 MSX data will be used to upgrade and validate the models of spatial structure and variability in infrared and optical backgrounds. The data will be transitioned to the SHARC and SAMM codes. Celestial background data will be transitioned to CBSD to provide stellar on-board calibration sources for advanced space-based surveillance and tracking systems.

* Major upgrades in the capabilities of the atmospheric optical background and transmission codes will be made during FY95-00 and transitioned to SMC and Aeronautics Systems Center (ASC).

  ** Key new optical background data from successful space shuttle and rocket-borne experiments (CIRRIS 1A, SKIRT I, II, and EXCEDE III will be transitioned to the optical background codes in FY96 and FY97.

  ** Models relating fluctuations in atmospheric temperature and density to spatial and temporal structure in infrared and optical background radiance will be developed and transitioned to CBSD and SHARC for high altitude applications in FY96 and to SAMM for all-altitude applications in FY97.

** The SAMM code will provide a seamless description of spatially structured backgrounds in both the lower and upper atmosphere as the simulation capabilities of the SHARC, MOSART, and MODTRAN codes are enhanced in FY 96-98. It will also be extended into the UV and millimeter wavelength regions in FY97-98.

* The PLEXUS code, which provides a user-friendly interface to all of the atmospheric background and transmission codes, will be updated yearly and transitioned to SMC and ASC during FY96-98.

* The breakthrough on understanding infrared emissions arising from high velocity atoms will be followed up. Laboratory and theoretical investigations will be performed to interpret new data from upper atmospheric field experiments on infrared emissions arising from these high velocity atoms and the results will be incorporated into infrared and optical background codes during FY96-98.

THRUST 2: GEOPHYSICS FOR AIR AND COMBAT OPERATIONS

USER NEEDS

The atmosphere plays a key role in the design and utilization of almost all Air Force systems and in their operational implementation. Therefore, User Needs related to this Thrust are pervasive and can be identified in many Mission and Functional Area Plans and in product center Development Plans. There are three sets of documents where weather requirements are explicitly described:

1. The Functional Area Plan (FAP) entitled, Air Force Weather Support System and the related ESC Technical Planning Integrated Product Team (TPIPT) on Weather. The prioritized Technology Needs identified in this process are as follows:

* Cloud Analysis and Forecasting Models; substantial improvement in spatial and temporal accuracy,
* Surface Weather Parameter Analysis and Forecasting Models; emphasis on visibility,
* Hazard Analysis and Forecasting Models: emphasis on turbulence, icing, and thunderstorms,
* Tactical Environmental Sensing; range of specific parameters in data-sparse regions,
* Atmospheric Models; forecast models focussed on parameters for air-base and battlefield support,
* Weather Impact Decision Aids; development of sensor-specific algorithms which accurately predict range of utility as a function of weather conditions
* Weather Radar Automated Forecasting Techniques; develop algorithms/models to infer severe weather from NEXRAD (WSR-88D) Doppler radar
* Far Term Applications Modeling; develop application models for centralized weather forecasting related to TBM, strategic enhancement/projection and National Program customers
* Advanced Climatological Modeling; climate spreading techniques needed to develop worldwide climatologies in data sparse/void regions

2. The AFSPC Mission Area Plan entitled, Force Enhancement and the related SMC TPIPT. The Weather Concepts identified in this process are as follows:

* National Polar Orbiting Environmental Satellite Sensors (NPOESS)
* DMSP Block V Sensors
* Small Tactical Terminals
* Wind Profile Sensor Suite
* Light Detection and Ranging Radar
* Millimeter Wave Radar
* Alternative Weather Systems

Technical Needs are identified for each of these Weather Concepts, but have not yet been defined in detail. These concepts require new sensor concepts and the related retrieval algorithms and software development to convert electromagnetic signals into the required weather and atmospheric parameters.

3. The AFSPC Mission Area Plan entitled, Space Forces Support and the related SMC TPIPT. The Range Standardization and Automation (Phase II) program in the TPIPT development plan requires improving weather data collection. Technology Needs include improving space-launch weather support by the forecasting of triggered lightning.

Lidar for remote sensing holds great promise for meeting the following needs:

* The 1992 AFMC Laser Mission Study identified the need to accurately measure winds aloft between an aircraft and the ground to aid in defining trajectories of bombs, cargo pallets, and projectiles fired from the aircraft,

GEOPHYSICS FOR AIR AND COMBAT OPERATIONS

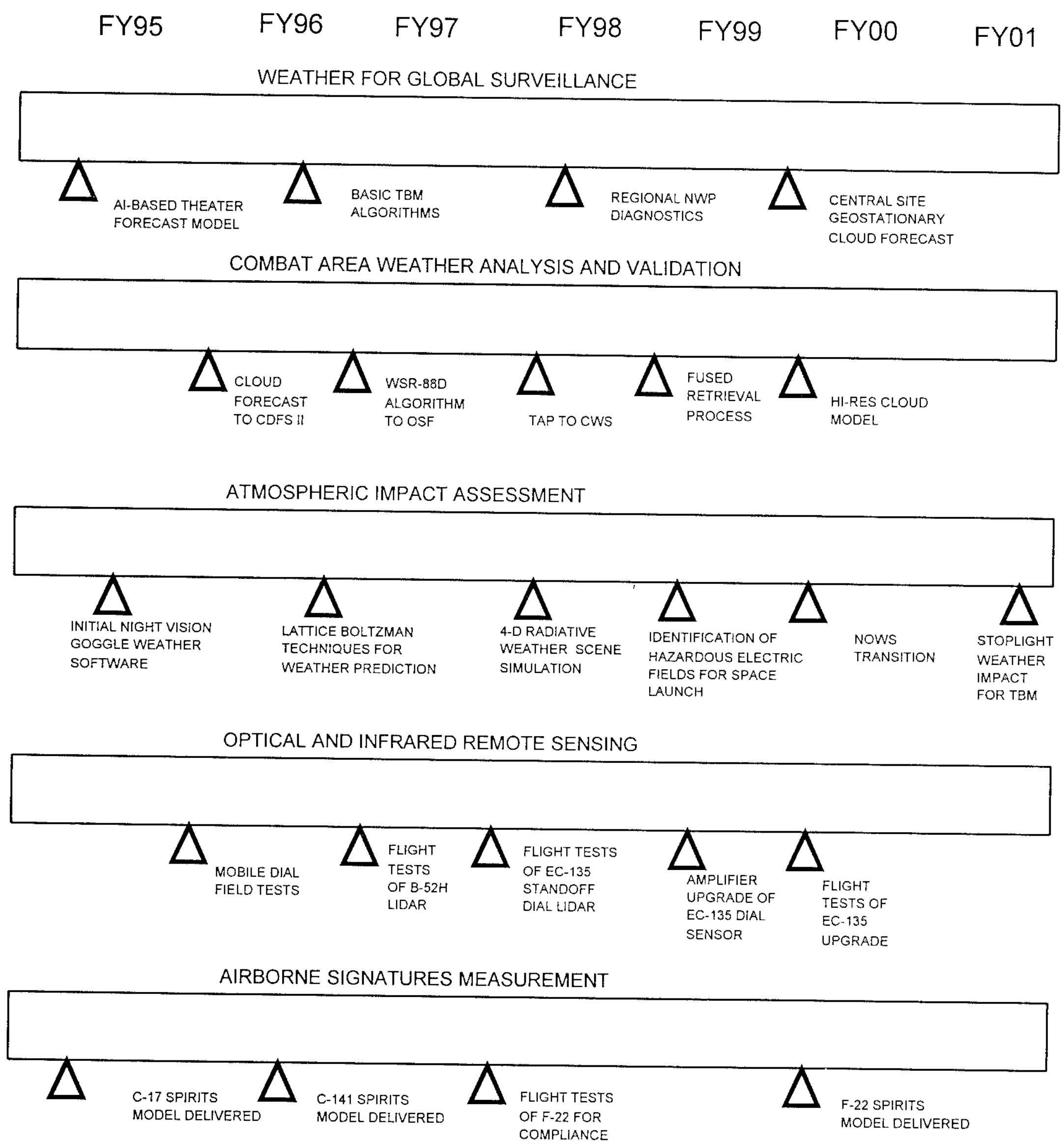


FIGURE 2.1 Geophysics for Air and Combat Operations

* ACC, AFSOC, and AMC expressed active interest in the development of techniques for the remote sensing of ballistic winds. Measuring winds from aircraft using Lidar is an intermediate step towards the ultimate objective of measuring winds aloft from DMSP and other weather satellites,

* DOD and several intelligence agencies support the application of Lidar for detection of chemical and biological agents. The system would be used for theater stand-off detection and for detecting fugitive emissions associated with production of

these agents for non-proliferation monitoring and treaty compliance, and

* Memorandum from the Joint Chiefs of Staff 154-86 identifies many requirements for the remote sensing of the environment from space. Some capabilities identified there cannot be attained through passive techniques.

Airborne Signature Measurements: Designers and developers of aircraft and missile systems have important needs for airborne measurements and support for model development. With the installation of improved visible and infrared instrumentation equipment into the new FISTA 2 platform, these and other short and long term measurement and modeling needs of the AF, Advanced Research Projects Agency (ARPA), and BMDO can be met. These needs include:

* F-22 Test Facility Requirements Document (TFRD), CDRL A085, May 1993 to support infrared specification compliance. ASC has tasked the FISTA program to measure and support IR modeling of the F-22, to establish an accurate IR simulation capability of the new aircraft. This will also enable threat, vulnerability, and survivability studies to be performed and will minimize the need for flight testing.

* AMC needs, for C-17 Airlift Defensive Systems, to develop a validated IR simulation model of the C-17 for testing of defensive flare systems. Development of simulation capability as early as possible in development and operational testing can greatly minimize costs by optimization of test planning and procedures.

* IR simulation is in extensive use by ACC as an aid in low observability threat analysis. Accurate and verified simulation capability allows maximum optimization of threat analysis before testing and operational verification on flight vehicles.

* The AF Information Warfare Center (AFIWC) requires a comprehensive measurement/model data base (PMD 0943(3)/28021F) on all non-foreign weapon systems. Our airborne measurements and model development are needed to eliminate critical deficiencies in their database requirements.

GOALS

The goals of this thrust, derived from the needs cited above, include:

* Exploit satellite-based remote sensing to obtain continuous, worldwide coverage and avoid data denial by unfriendly countries.

* Combine advanced multi-satellite cloud retrieval techniques into cloud analysis models for centralized and theater weather centers.

* Accurate and reliable short-term (0-6 hrs) high resolution cloud forecasts globally.

* Development of new Weather Impact Decision Aid in support of EO system/smart weapon employment and mission planning.

* Mission planning and deployment decisions based on timely and accurate weather information.

* Accurate cloud and weather simulation for any world-wide location.

* Develop new technologies to fully exploit the capabilities of new operational doppler weather radars.

* Measurement of atmospheric wind fields from surface and aircraft lidar platforms for ballistic wind applications.

* Lidar technology for stand-off detection of chemical and biological agents and for chemical and biological treaty compliance.

* Transmitter and signal processing lidar hardware for space-borne wind sensing.

* High fidelity, quantitative airborne target and background measurements for target signature phenomenology determination.

* Extend our target modeling capability to include the visible and ultraviolet spectral regions, more accurately model reflective signatures, such as sun glints, and more accurately model low

observable surfaces properties and special coatings.

* Interface our phenomenology based predictive models into existing or developmental engagement models, providing accurate target and background signatures for a wide variety of operational and environmental conditions.

MAJOR ACCOMPLISHMENTS

A comprehensive infrared predictive model of the C-17A cargo aircraft was developed based on extensive in-flight measurements. This SPIRITS model incorporated innovative plume enhancements for the C-17A's high-bypass turbojet engines, flap heating from thrust diverting flaps, and the MODTRAN3 and MOSART environmental models. Model predictions were generated to drive the AFEWES hardware-in-the-loop simulator for flare effectiveness studies, as well as planned inclusion in missile flyout models such as DISAMS and MOSAIC.

A prototype Night Vision Goggle (NVG) Air Refueling Decision Aid was delivered. Target scenes were developed for the advanced electro-optical (EO) weather impact decision aid. Technology for a new Base Weather Station was developed and the battlefield utility of the tactical weather observations sensors was demonstrated. Models were developed for a limited data, first-in, battlefield weather forecast and for a Tactical Forecast System (TFS).

Fully documented research algorithm codes for a multi-satellite, multispectral high resolution global cloud analysis mode were transitioned to SMC for use in the Cloud Depiction and Forecasting System acquisition for Air Force Global Weather Central (AFGWC) where they will provide a real-time global support to mission planning and national programs.

Developed and validated a new, more accurate adaptive elliptic model of mesocyclone structure as detected by Doppler weather radar. The new model may lead to substantially more accurate severe weather algorithms for safety and resource protection of DOD assets.

Successfully completed calibration flight programs that demonstrated the robustness of radiation measurements from DMSP SSM/T-2 water vapor sounders on vehicles F11 and F12 to meet AF, DOD, and national program requirements.

The initial capability of IR scene visualization that will be included in the Air Force Mission Support System (AFMSS) was demonstrated. These visualizations will be used by pilots to plan and rehearse missions involving IR precision-guided munitions.

Radar-measurable parameters related to electric fields in thunderstorms were identified and quantified. These results will contribute to development of a capability to remotely identify hazardous electric fields in clouds that can adversely impact aviation and space launch operations. Present inadequate knowledge requires conservative guidelines that frequently impact Shuttle and other launches.

Targeting accuracy improvements were successfully demonstrated with ballistic winds data from a ground based lidar in conjunction with AC-130H gunship live-fire and B-52G high altitude bombing exercises.

Delivered extensive IR SPIRITS C-17A prediction results for the AFEWES hardware-in-the-loop simulation system in support of the AMC. These prediction results were critical in evaluating flare countermeasure effectiveness against operational missile seekers.

CHANGES FROM LAST YEAR

The program to develop and evaluate Tactical Weather Observations sensors was completed and the results transitioned to AWS, ending the advanced development program in Tactical Weather Observing Systems (TWOS) ahead of schedule.

The moisture analysis and cloud forecasting effort will change to include Contrail specification and forecasting. Use of GPS radio-occultation to infer atmospheric temperature and humidity will be studied.

The Otis Air National Guard Base Weather Test Facility will convert from testing of Tactical Weather Sensors to evaluation of Night Vision Goggle Operations Weather Software (NOWS), and IR target/background thermal contrast models.

The Cloud Scene Simulation program will be reduced due to funding and manpower reductions.

An enhanced instrumentation suite was reinstalled in the new FISTA 2 platform. Extensive modifications to the new platform were accomplished and the FISTA capability returned to service in FY95.

MILESTONES

An advanced Parameter Global Cloud Analysis Model will be delivered to SERDP in FY96.

The potential of Lattice Boltzman parallel processing to revolutionize numerical weather prediction will be evaluated in FY96.

Severe weather algorithms for severe weather, precipitation structures, tornados, hail, weather fronts, lightning, and other aviation weather hazards will go to the WSR-88D OSF in FY96 and 97. Severe weather prediction software development will continue into FY99.

A capability to simulate 4-dimensional radiative weather scenes for IR sensors and NVG WIDAs will be developed in FY97. Development of global and theater weather analysis, simulation, and prediction techniques for combat weather system applications will continue through FY01.

A theater-scale analysis procedure for EOTDA support, combat weather displays and forecast model initialization will be completed in FY97. The development of the Tactical Forecast System (TFS) technology will continue through FY97.

Techniques to identify hazardous electric fields in clouds for improved vehicle launch capabilities will be transitioned to AFSPC in FY98.

A retrieval process for fused infrared and microwave data for atmospheric and surface parameters will be completed in FY98.

NOWS will transition to AFSOC and ACC in FY99.

Stoplight weather impact mission planning software will be transitioned to TBM system in FY01 as part of the Centralized Weather Support technology effort.

Measurements of effluent plumes and chemical clouds by an airborne Lidar will continue through FY99. Ground and flight tests will be made using stand-off measurements in the long wave infrared (LWIR) and medium wave infrared (MWIR) of chemicals using direct and heterodyne detection. Later tests will include flight tests of a high energy, long range, prototype system. Evaluations will be made during the above tests for suitability to space based remote sensing applications of the technologies developed.

The FISTA facility will continue to collect infrared signatures on various aircraft and selected missiles to expand and validate the SPIRITS code in FY97 and beyond. This will include measurements of the F-22 in the FY98-FY00 period. FISTA will also provide a research test bed for flight measurements utilizing advanced measurement techniques. These include measurements of aircraft turbulence, aircraft engine atmospheric contamination products, or prototype testing of new IR sensing systems, such as hyperspectral/spatial sensors.

The FISTA mission may be expanded to include airborne testing of Lidar in FY96.. The Lidar sensors installed aboard FISTA will support the FISTA optical measurements mission by providing optical path characterization data from FISTA to the target.

Future ballistic winds tests of bombs dropped from B-52s will include a Lidar installed in a B-52 making real time bombing corrections.

THRUST 3: GEOPHYSICS WITH CORPORATE APPLICATIONS

USER NEEDS

FY93 Congressional legislation mandated the US negotiate a multilateral Comprehensive Test Ban Treaty (CTBT). The President's commitment to this is contained in Presidential Decision Directive No. 18 signed 20 Dec 93, outlining new requirements for the Air Force Technical Applications Center (AFTAC) to monitor foreign nuclear tests. These requirements are significantly more challenging than before.

The Geophysics Directorate's Office of Environmental Simulation has broadened its approach to provide a range of environmental simulation support and services to work with:

* DMSO,
* Air Staff (AF/XOM and AF/XOW),
* HQ AFMC,
* Space Warfare Center, and
* Electronic Systems Center (ESC)

These large users have a pressing need to access an entire suite of geophysical codes with a user friendly interface. The expert systems Geophysics is developing will satisfy the user's needs to have not only the 'best' model for their application, but assurances that interfacing to the whole suite of environmental codes will be a one-time process. Geophysics also benefits in that the model developers are only concerned with a single interface to the expert system. Both code developers and users may also benefit by re-using previously developed software. Our commitment to users of a single code remains high as well. While single code users may not need an expert system, it may save them a great deal of time in the long run. The expert system approach lets us support a large number of users with very different uses for our codes.

Users need codes that can realistically generate scenarios. The user may want to:

* Simulate an air strike over North Korea,
* Revisit Desert Storm to see how new weapons would work,
* Change weather patterns.

Environmental quality has a direct impact on the AF warfighter mission. AF facilities and bases that are in compliance with all laws will be granted operating permits more quickly and cost-effectively than non-compliant facilities. Reducing the cost of clean-up efforts will permit more funding to support weapons systems development. Steps taken to prevent pollution will significantly reduce the life-cycle costs of new systems. The Environmental Safety and Occupational Health (ESOH) TPIPT solicits environmental needs from MAJCOMS, Product Centers, Systems Program Offices, and Logistics Centers. The Geophysics for Environmental Quality Sub-Thrust addresses many high priority needs from the ESOH TPIPT survey in the areas of:

* technology to meet Clean Air Act Amendment monitoring requirements for toxic and hazardous gases in the atmosphere,
* detection and monitoring of dense non-aqueous phase liquids,
* non-CFC fire extinguishing systems,
* monitoring the effect of rocket exhaust on the stratosphere, and
* other similar needs.

The Air Force Center for Environmental Excellence (AFCEE) also has needs for remote, rapid-response characterization of underground hazardous waste sites and for real-time site monitoring. Finally, we anticipate the eventual need to monitor and understand the impact of AF systems on the global environment and on site specific pollution and are maintaining a core capability to address such needs in the future.

GOALS

The goals of the Terrestrial Effects on Air Force Systems Sub-Thrust are:

* Improved capability to monitor clandestine underground nuclear tests. Development of accurate attenuation and magnitude factors needed by AFTAC to estimate the size and characteristics of seismic events suspected to be underground nuclear explosions.

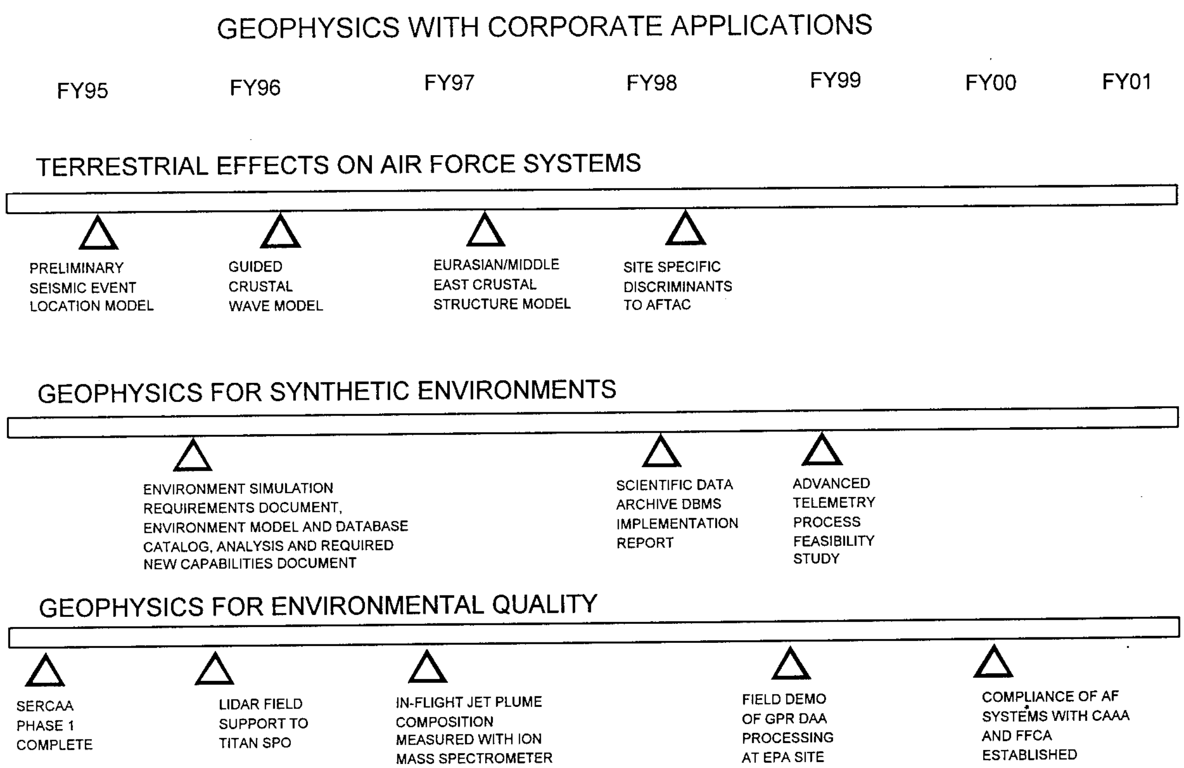


FIGURE 3.1 Geophysics with Corporate Applications

* Formulation of new seismic source models for complex seismic source phenomena such as quarry blasts and rockbursts.

* Adaptation of new signal processing techniques to improve the capability of AFTAC's seismic arrays.

The goals of the Geophysics for Synthetic Environments Sub-Thrust are:

* A capability to provide time variation scenarios for either past conditions (i.e. a replay of a real weather/weather effects day from DESERT STORM) or predicted conditions (i.e. construct a scenario of a 3-day event where the weather-/weather effects change realistically, say a cold-front passage, or a precipitation event, etc)

* Models that simulate the space environment during all phases of solar activity.

* Environment representation models that are computationally fast, and have a capability for simulating conditions over large geographic areas as well as a specific battlefield.

* Models that can generate synthetic weather data for data sparse areas of the globe.

* A capability to portray realistically and accurately environmental phenomena such as clouds in the visible as well as in all electro-optical wavelengths in which military systems operate.

The goal of the Geophysics for Environmental Quality Sub-Thrust is to provide technology to establish compliance of AF equipment and operations with environmental laws, to minimize the impact of Air Force operations on the global and local environment, and to reduce significantly the cost of environmental clean-up. Specific goals are:

* Characterize the chemical composition of the exhaust plumes of rocket and jet engines using

new mass spectrometric techniques for in-situ air emission measurements;

* Develop ground-based optical techniques for remote detection, mapping and tracking of hazardous chemicals, aerosols, and stratospheric ozone depletions associated with Air Force operations;

* Adapt seismic data analysis techniques to ground penetrating radar (GPR) for geological characterization of underground hazardous waste sites and develop data fusion techniques for site characterization;

* Adapt and exploit Geophysics Directorate atmospheric transmission codes to predict the effect of pollutants on the earth's radiation balance and to understand issues such as potential global warming.

MAJOR ACCOMPLISHMENTS

The Geophysics Directorate signed an interagency agreement with the Department of Energy (DOE) to manage its external seismic monitoring research program. This program's objective, which is also funded by ARPA and AFTAC, is to improve the capability of the US to monitor a CTBT.

The Geophysics Directorate concluded an agreement with ASC to be the single focal point for environmental representations for AFMC's Joint Modeling and Simulation System (J-MASS) a standard digital modeling and simulation capability with which to test and assess the capabilities of weapons systems in a simulated operational environment. The Directorate will provide the initial IR atmospheric code (MODTRAN) for the J-MASS release 3.0 (previous versions were test versions) to the community. The important point to remember is that the Directorate is providing MODTRAN through the PL Expert User System (PLEXUS) interface. Since J-MASS has a need to incorporate radar, laser, and many more weapons systems, we are positioned to add the appropriate codes to the PLEXUS 'backside' so that the J-MASS 'frontside' will be as undisturbed as possible.

Geophysical codes were provided to the DOE Argonne National Laboratory as part of a continuing effort to provide support to Joint Staff and Air Staff initiatives. The Dynamic Environment Effects Model (DEEM) is an Argonne model that the Joint Staff (J-8) and the Air Staff (AF/XOW/XOM) are looking at two distinct applications. In the former case, DEEM is part of a J-8 effort to provide environmental effects to training (unit level and individual level) activities and wargaming (large distributed simulations) activities. We expect to be able to provide most if not all the geophysical models DEEM will use to satisfy J-8. In the second case, a DEEM implementation for theater weather modeling is being pursued by AF/XOW. It is not clear how (or if) our geophysical codes will be a part of this effort at this time. We are in the process of determining if the XOW effort may lead to operational planning decision simulations where our codes would be valuable.

Significant progress has been made in the Directorate's support to DMSO's Environmental Effects for Distributed Interactive Simulation (E2DIS) project. The customer surveys have been published and distributed and a number have been received back. Work has progressed steadily in producing ionospheric modeling, space modeling, and atmospheric transmission modeling deliverables for the sub-tasks within E2DIS. Funding for these tasks was delayed until the fall of 1994 (50 percent increment) and Feb 95 (final 50 percent increment). An additional task, using cloud scene simulation model (CSSM) was added in the fall of 1994.

Development of innovative techniques to quantify trace gas composition in the atmosphere continued in FY95. Such techniques are directed toward establishing compliance of Air Force systems and operations with regulations such as Title 3 of the Clean Air Act Amendment of 1990.

A proposal to save the stratospheric ozone layer from destruction by CFCs, by converting atomic chlorine to benign negative ions, was shown to be not feasible. Geophysics researchers proved that chlorine negative ions are not stable in the stratosphere, potentially saving millions of US research dollars which might have been used to pursue the idea.

The suite of Air Force line-of-sight radiative transfer codes was used in FY95 to calculate the effect of cloud layers on atmospheric heating and cooling rates. This work directly lead to the realization that

the MODTRAN-3 code could be expanded to address multiple scattering of radiation within cloud layers such as sub-visual cirrus. The MODTRAN code would permit more accurate assessments of the delectability of theater missiles as observed from aircraft in realistic environments.

A novel four-frequency differential absorption Lidar (DIAL) technique was implemented in a field experiment for the first time in FY95. The method will be used to measure the extent of stratospheric ozone depletion following Titan rocket launches, and may ultimately produce accurate neutral densities from ground level to the mesopause in support of space tracking operations.

Phase 1 of the SERCAA program was completed. The Phase 1 algorithms will be transitioned to the DOD Satellite Analysis Central Site for inclusion in the Cloud Depiction and Forecast System - II, an advanced global weather analysis and prediction system for support of military operations.

Advancements to the environmental data fusion system included cross hole seismic survey modeling techniques to show subsurface structures.

CHANGES FROM LAST YEAR

The Titan Program Office (SMC/ME) initiated a new program with the Geophysics Directorate in FY95 to address the environmental effects of launch operations. Ozone depletion caused by exhaust deposition in the stratosphere will be accurately measured using both ground-based Lidar and aircraft-based mass spectrometry techniques. Based on model analyses, the World Meteorological Organization determined and published the conclusion that the ozone depletion caused by worldwide launch vehicle operations is not globally significant. It is also believed that any local effect is transitory at best. The Lidar and mass spectrometer will help verify these conclusions. In addition, the codes needed to model toxic hazard launch corridors will be validated using a separate infrared Lidar system.

In response to a change in SERDP program direction, the Environmental Quality Subthrust is de-emphasizing Global Environmental Change Research in FY96.

MILESTONES

Techniques for identifying seismic phases from high priority geographic regions of interest will be delivered to AFTAC in FY96 for analyzing surface waves using array methods and for examining the radiation from cavity decoupled explosions. A physical model for guided crustal waves for applications in the Eurasian and Middle East Region will be delivered in FY96 and a model of the Eurasian and Middle East crust and mantle structure will be delivered in FY97 to improve capabilities for monitoring these areas.

The Geophysics Directorate will provide the first of what is presumed to be an expanding suite of geophysical models to AFMC's J-MASS upon J-MASS release 3.0 in May 95. PLEXUS will be provided to be the single point of interface with MODTRAN under this release. A schedule of additional atmospheric models for radar, high altitude, etc is being worked out by the J-MASS program office.

Work on the E2DIS deliverables to DMSO will be completed in FY96.

Development of clean-air compliance measurement techniques will continue in FY96-97. Novel instruments will be used in FY96 at WL to measure the possible toxicity of HALON replacements proposed for flight-line fire suppression use. The instruments will also be used in FY96-99 to measure the concentrations of Titan rocket exhaust species that participate in the stratosphere.

Geophysics Directorate Lidar systems will be deployed in FY96-97 to Kennedy Space Center and to Vandenberg AFB to measure the transitory effect on the ozone layer caused by Titan launch and to measure dispersion of exhaust species near the launch site. These measurements will confirm the Titan launch systems compliance with present and future environmental regulations.

In FY96, the SERCAA Phase 2 program will provide cloud environment parameters such as vertical temperature and moisture profiles, surface temperature, and cloud liquid water content using DMSP SSM/T-2, SSM/I, TIROS Operation Vertical Sounder (TOVS), and GEOSTATIONARY satellite sensors.

Seismic signal processing techniques will be applied to GPR data to enhance its resolution in the shallow sub-surface region and improve confidence in depth-of-target and surrounding structure information. This will provide the data required to design less costly site remediation programs.

Development of the environmental data fusion system will continue in FY96 to achieve rapid response to dynamic, site-specific environments and to support field operations in real time. Transition to the AFCEE will take place in FY97.

GLOSSARY

50WS	50th Weather Squadron(formerly Air Force Space Forecast Center)
ABL	Airborne Laser
ACC	Air Combat Command
ADS	Atmospheric Density Satellite
AFCEE	Air Force Center for Environmental Excellence
AFESES	Electronic Warfare Effectiveness Simulator
AFGWC	Air Force Global Weather Central
AFMC	Air Force Materiel Command
AFOSR	Air Force Office of Scientific Research
AFSATCOM	Air Force Satellite Communications
AFSFC	Air Force Space Forecast Center
AFSOC	Air Force Special Operations Command
AFSPC	Air Force Space Command
AFTAC	Air Force Technical Applications Center
AFWPP	Air Force Weather Program Plan
AI	Artificial Intelligence
AMC	Air Mobility Command
APEX	Advanced Photovoltaic and Electronics Experiment
ASC	Aeronautics Systems Center
AWS	Air Weather Service
BDC	Background Data Center
BMDO	Ballistic Missile Defense Organization
C3I	Command, Control, Communications and Intelligence
CAA	Clean Air Act
CBSD	Celestial Background Scene Descriptor
CCS	Charge Control System
CEASE	Compact Environmental Anomaly Sensor
CFC	Chlorofluorocarbon
CHAWS	Charge Hazards and Wake Studies
CIRRIS	Cryogenic InfraRed Radiance Instrumentation for Shuttle
CRADA	Cooperative Research and Development Agreements
CRES	Compact Radiation Effects Satellite
CRRES	Combined Release and Radiation Effects Satellite
CTBT	Comprehensive Test Ban Treaty
DEEM	Dynamic Environment Effects Model
DIAL	Differential Absorption Lidar
DISAMS	Digital Infrared Seeker and Missile Simulation
DMSO	Defense Modeling & Simulation Office
DMSP	Defense Meteorological Satellite Program
DOD	Department of Defense
DP	Development Prototype
DSCS	Defense Satellite Communication System
E2DIS	Environmental Effects for Distributed Interctive Simulation
EPA	Environmental Protection Agency
ESC	Electronics Systems Center
ESOH	Environmental Safety and Occupational Health
EXCEDE	EXcitation by Electron DEposition
FISTA	Flying Infrared Signatures Technology Aircraft

FLTSATCOM	Fleet Satellite Communications
FY	Fiscal Year
GP	Geophysics
GPR	Ground Penetration Radar
GPS	Global Positioning System
HAARP	High Frequency Active Auroral Research Program
HF	High Frequency
HITRAN	High-Resolution Molecular Data Base
IBSS	Infrared Background Signature Survey
IFM	Ionospheric Forecast Model
IR	Infrared
IRAD	Industrial Research and Development
ISEM	Integrated Space Environment Model
J-MASS	Joint Modeling and Simulation System
JDL	Joint Director of Laboratories
LWIR	Long Wave Infrared
MAJCOM	Major Commands
MASC	Modeling and Simulation Center
MILSTAR	Military Communications Satellite
MODTRAN	MODerate Resolution TRANsmission
MOSAIC	Modeling System for Advanced Investigation of Countermeasures
MOSART	Moderate Spectral Atmospheric Radiance and Transmittance
MSFM	Magnetospheric Specification and Forecast Model
MSX	Mid-course Space eXperiment
MWIR	Medium Wave Infrared
NASA	National Aeronautical and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NORAD	North America Air Defense Command
NOWS	Night Vision Goggle Operations Weather Software
OTH-B	Over the Horizon Backscatter Radars
PASP Plus	Photovoltaic Array Space Power Diagnostics
PE	Program Element
PL	Phillips Laboratory
PLEXUS	Phillips Laboratory EXpert Unified Simulator
PRISM	Parameterized Real Time Ionospheric Specification
RASWS	Remote Access Scintillation Warning System
RF	Radio Frequency
RL	Rome Laboratory
S&T	Science and Technology
SAMM	SHARC and MODTRAN Merged
SBIR	Small Business Innovative Research
SERCAA	Support of Environmental Requirements for Cloud Analysis and Archive
SHARC	Strategic High Altitutde Radiance Code
SIMLAB	Simulation Laboratory
SKIRT	Spacecraft Kinetic InfraRed Test
SMC	Space and Missile Systems Center
SPIRIT	SPatial/spectral Infrared Rocketborne Interferometric Telescope
SPIRITS	Spectral In-band Radiance Images of Targets and Scenes
SPO	System Program Office
SPREE	Shuttle Potential and Return Electron Experiment
SSGM	Strategic Scene General Model

STIG	Space Technology Interagency Group
SWATH	Space Weather and Terrestrial Hazards
SWIM	Solar Wind Interplanetary Measurements
SWIPE	Space Waves in Plasmas Experiment
SWIR	Short Wave Infrared
TA	Technology Area
TAP	Technology Area Plan
TBM	Theater Battle Management
TEC	Total Electron Content
TMD	Theater Missile Defense
TN	Technology Need
TPIPT	Technical Planning Integrated Product Team
USAEDS	United States Atomic Energy Detection System
USSOUTHCOM	US Southern Command
USSPACECOM	United States Space Command
UV	Ultraviolet
VIPER	Visual Photometric ExpeRiment
VSH	Vector Sperical Harmonic
WBMOD	Wide Band Scintillation Model
WSR-88D	Air Force Next Generation Doppler Weather Radar (Operational)

Note

This, and next, page contain a Technology Master Process Description.

Note

This, and previous, page contain a Technology Master Process Description.

INDEX